Prospective Observational Study of Ocular Health of International Space Station Astronauts

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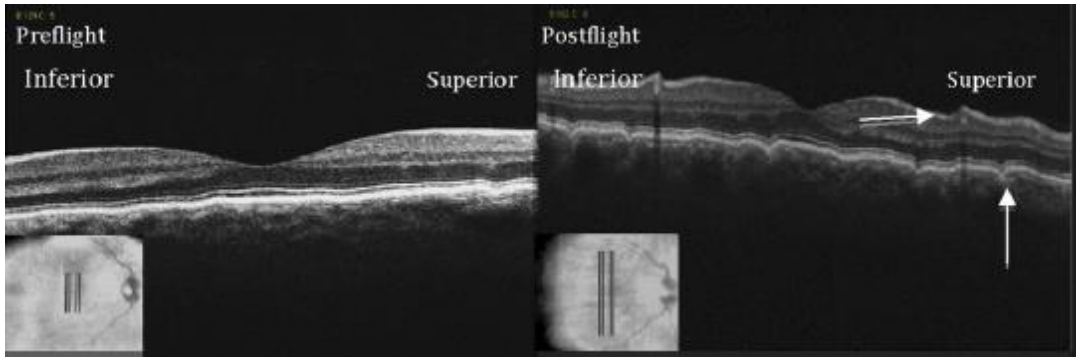
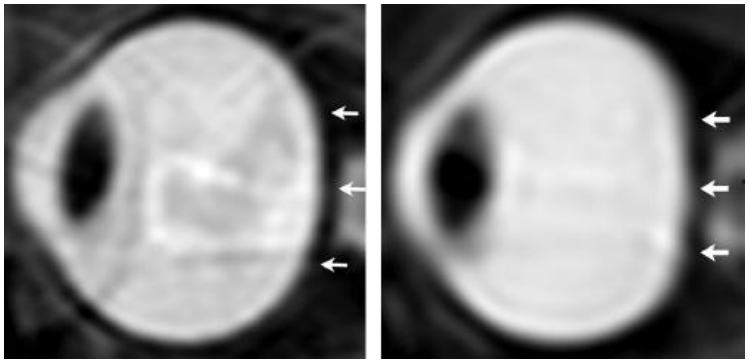
Ocular Clinical Findings

~35-50% U.S. operating segment astronauts have developed some or all of the following findings during or after long-duration spaceflight:

- Optic disc edema
- Hyperopic shift
- Choroidal folds
- Optic nerve sheath distention
- Optic nerve kinking
- Globe flattening



Mader et al 2011



Kramer et al 2012

Ocular Health Study

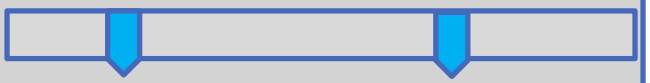
Purpose: Characterize the time course of ocular, cerebral, and cardiovascular changes that occur during ISS missions and their recovery post-flight.

Methods:

- Medical ocular data (MedB) collected pre-, in-, and post-flight
  - ✓ Flight Medicine Clinic
  - ✓ UTMB Victory Lakes
  - ✓ Coastal Eye Associates
  - ✓ ISS
- MedB and complementary data collected at additional time points
- 11/13 crewmembers have completed pre-, in- and post-flight testing
  - ✓ Optic disc edema: 2/13 crewmembers (15.4%)
- Preliminary data for 6 subjects (1 case) will be presented

Timeline

Pre-flight Exams



L-21/18 mo | L-12-3 mo

Flt Med. Clinic

- Vision Testing*
- Fundoscopy
- Refraction
- Pupil Reflexes
- Extra-Ocular Muscle Bal.
- IOP (Tonometry)

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- IOP (Tonometry)
- Ocular Ultrasound

Coastal Eye Associates

- OCT
- Biomicroscopy/ Hi Res Photogr.

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UTMB Victory Lakes

MRI

Cardiovascular & Vision Laboratory

- Cardiac Ultrasound
- Blood Pressure
- Transcranial Doppler Ultrasound

In-flight Exams

L+10 | L+30 | L+60 | L+90 | L+120 | R-30

ISS

- Vision Testing*
- Fundoscopy
- IOP (Tonometry)
- Ocular Ultrasound
- OCT
- Cardiac Ultrasound
- Blood Pressure
- Transcranial Doppler

MedB Sessions

Added Research Sessions

Post-flight Exams

R+1-3 | R+30 | R+90 | R+180 | R+365

Flt Med. Clinic

- Vision Testing*
- Fundoscopy
- Refraction
- Pupil Reflexes
- Extra-Ocular Muscle Bal.
- IOP (Tonometry)
- Ocular Ultrasound
- Blood Pressure

Coastal Eye Associates

- OCT
- Biomicroscopy/ Hi Res Photogr.

UTMB Victory Lakes

MRI

Cardiovascular & Vision Laboratory

- Cardiac Ultrasound
- Blood Pressure
- Transcranial Doppler Ultrasound

*Vision Testing includes Visual Acuity, Amsler Grid, Contrast Sensitivity, & Threshold Visual Fields. The latter is measured at Coastal Eye for ground testing.

Inflight Vision Testing

Fundoscopy

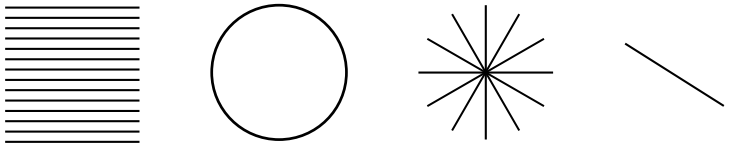
Optical Coherence Tomography (OCT)

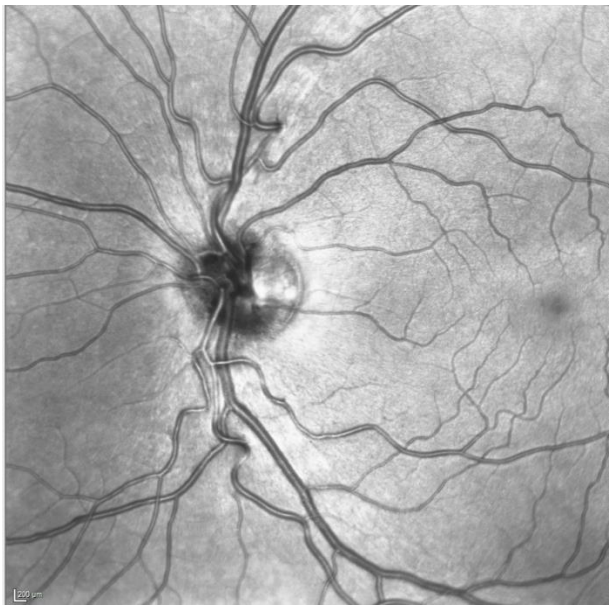
Images from www.nasa.gov

OCT Scan Patterns

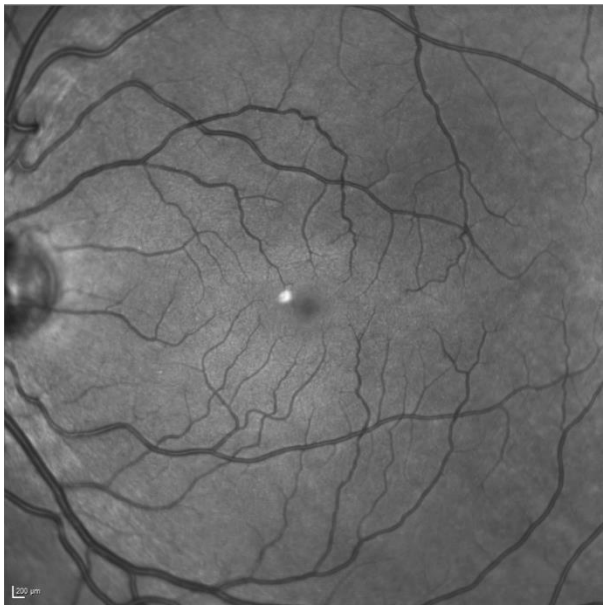
Scans taken in both eyes:

Centered over optic nerve head





Centered over macula

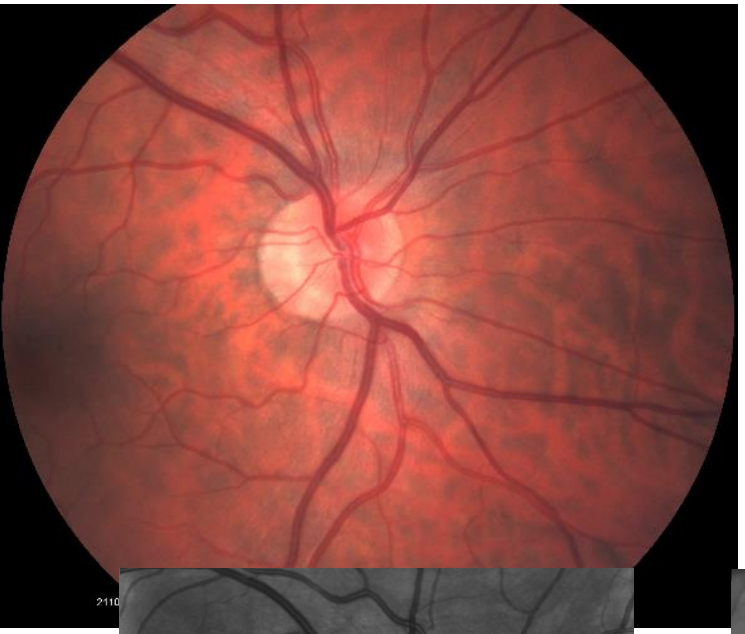


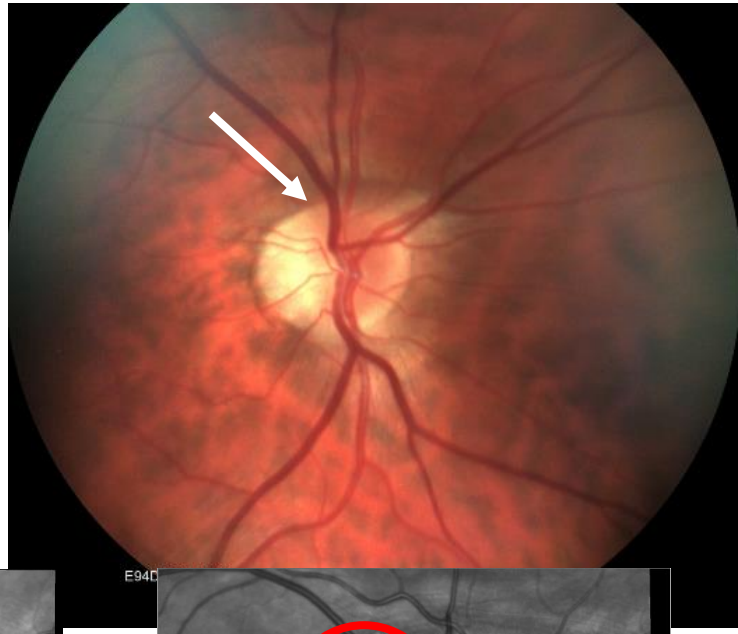
Case: Right Eye

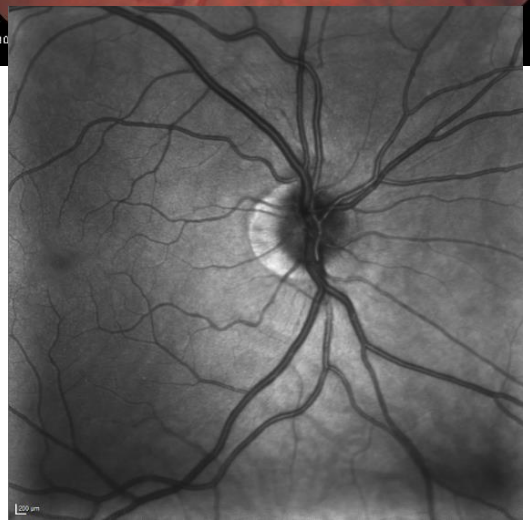
Pre-flight

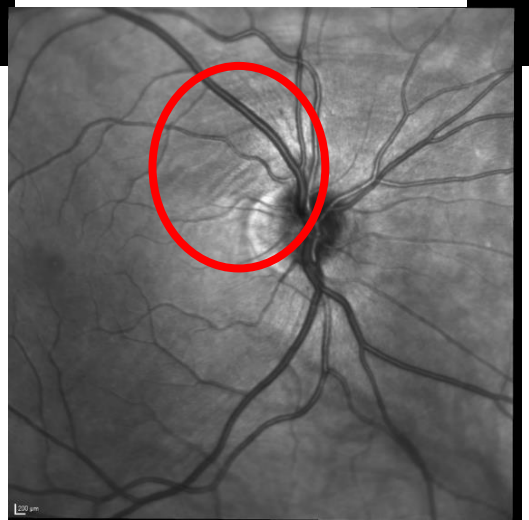
FD90

R-30



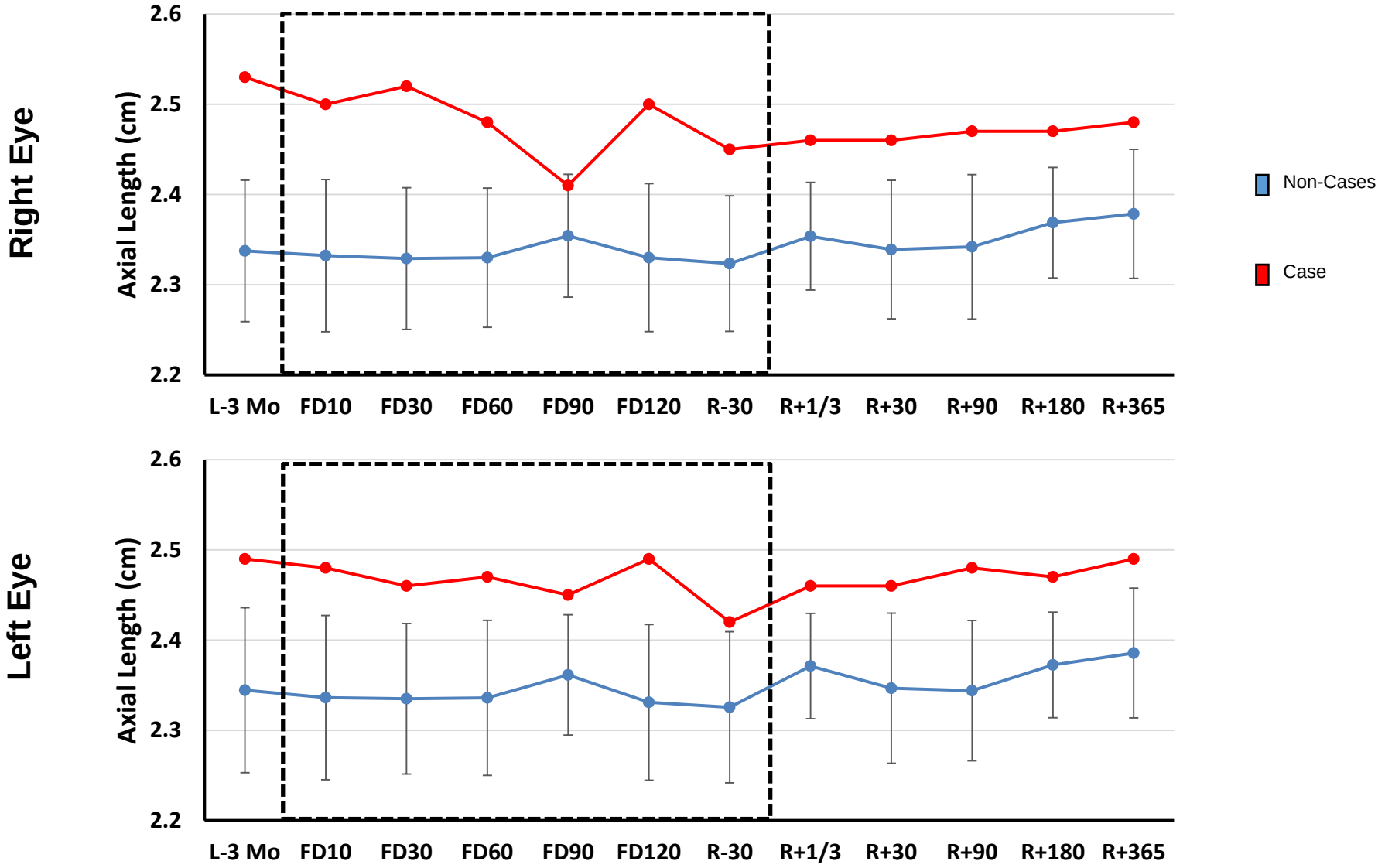






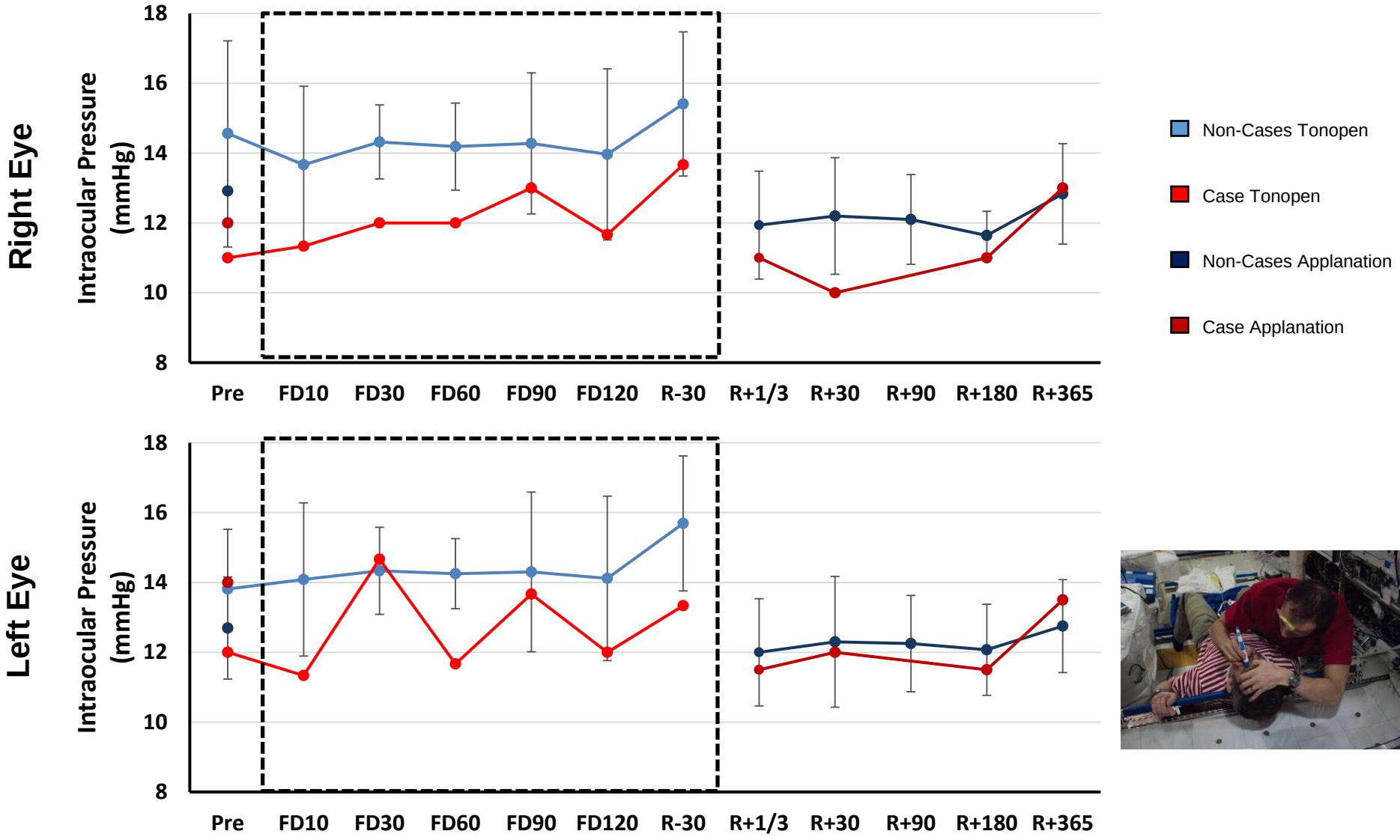
Axial Length

Preliminary Data



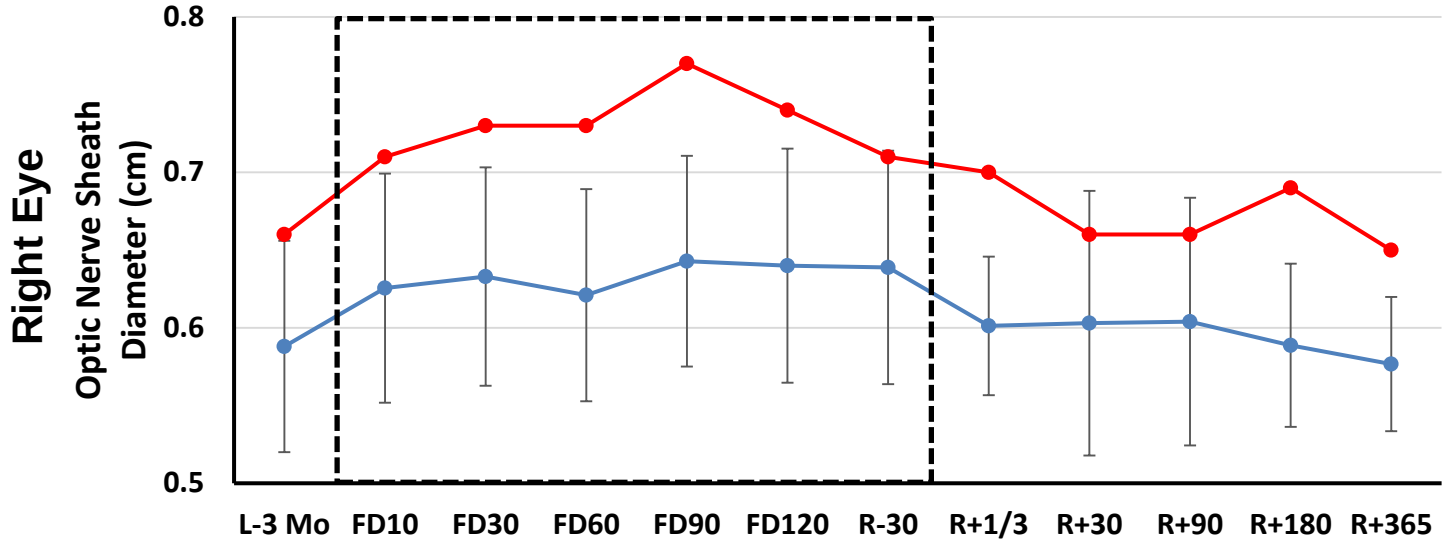
Intraocular Pressure

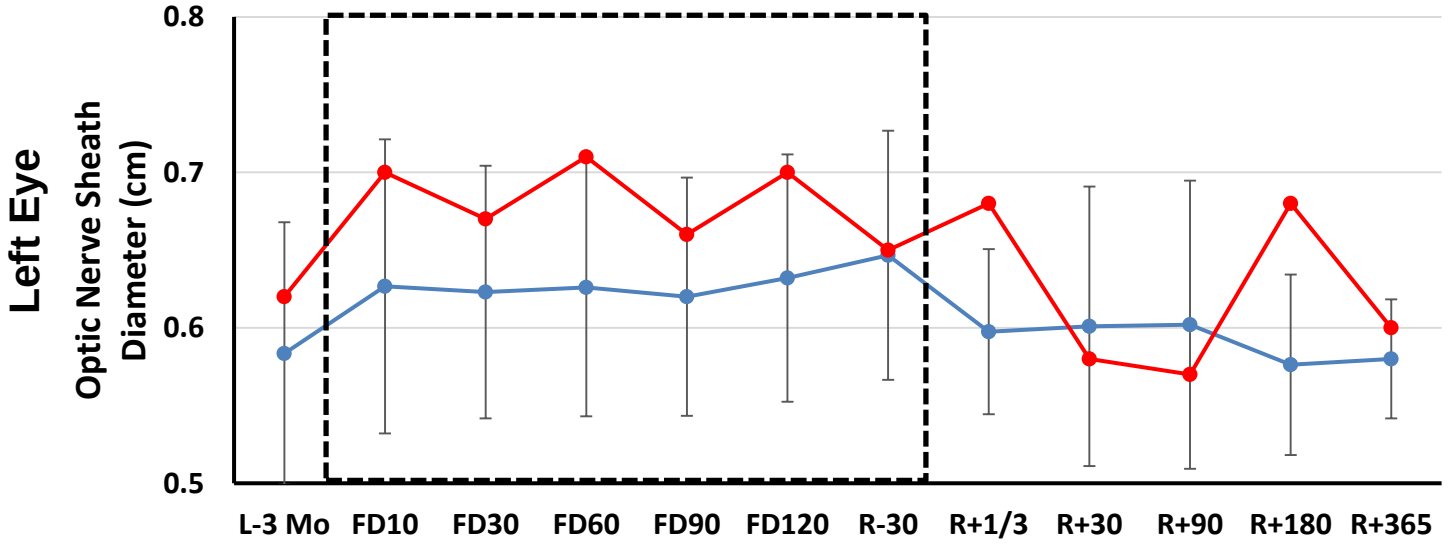
Preliminary Data



Optic Nerve Sheath Diameter

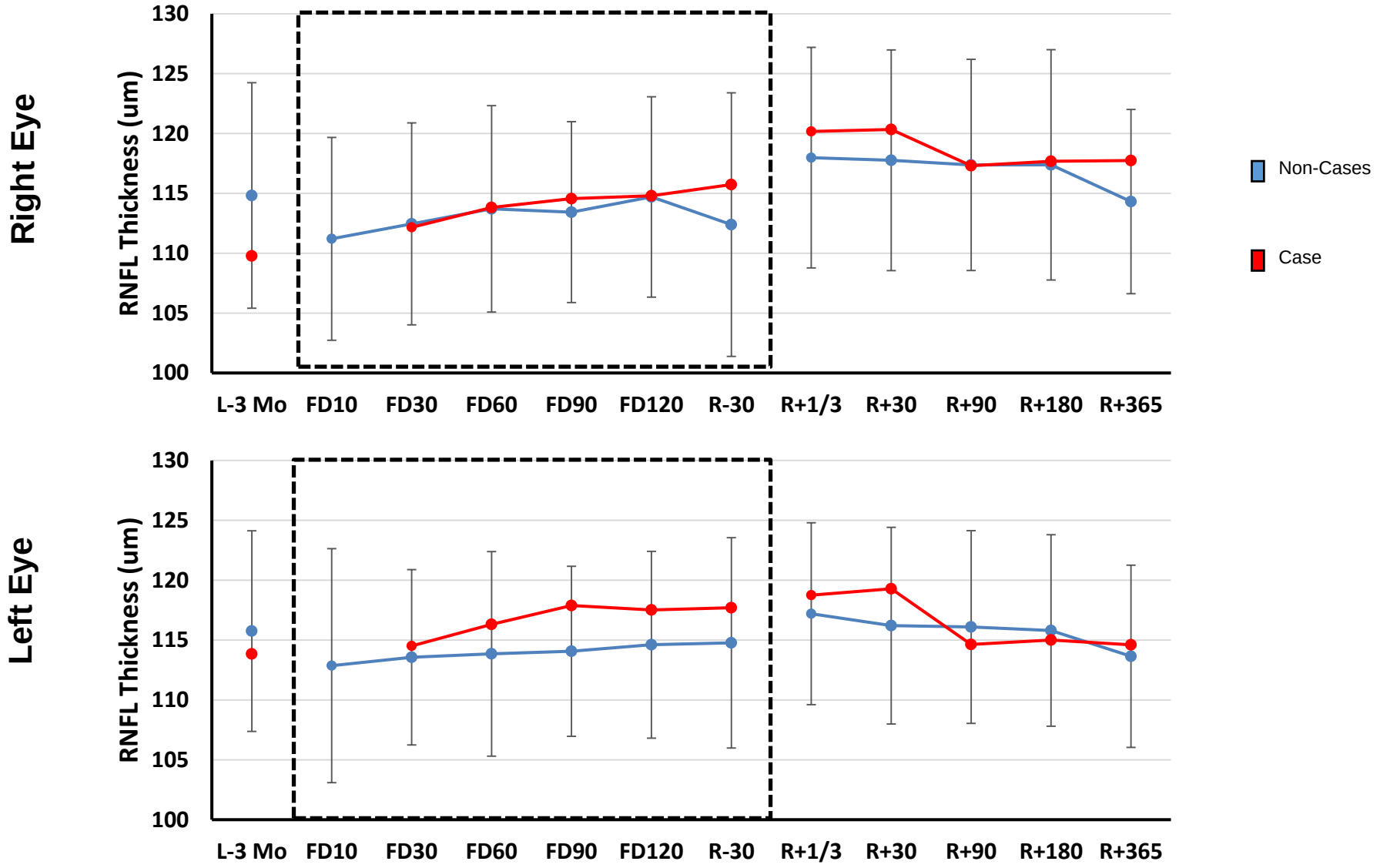
Preliminary Data





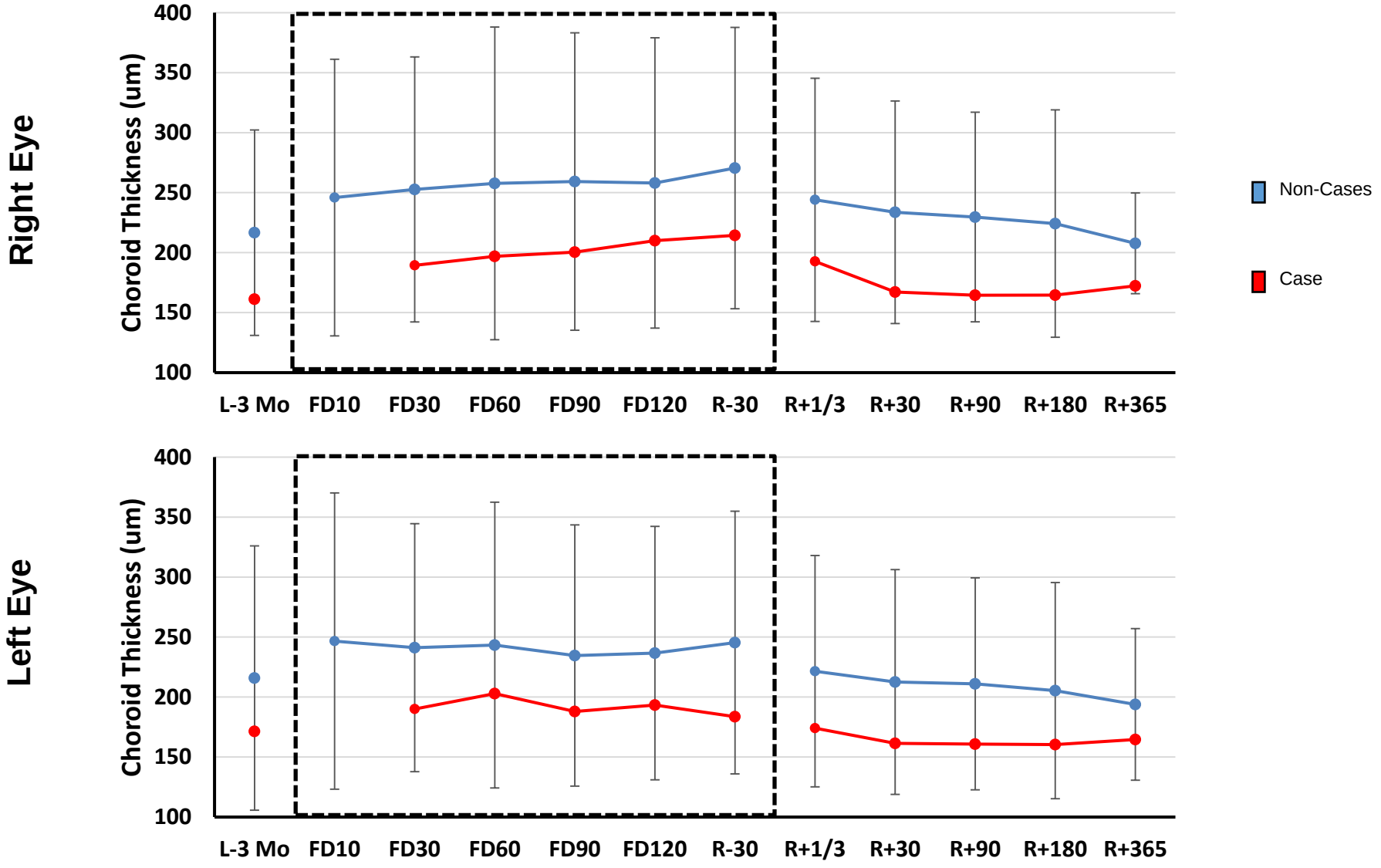
Retinal Nerve Fiber Layer Thickness

Preliminary Data



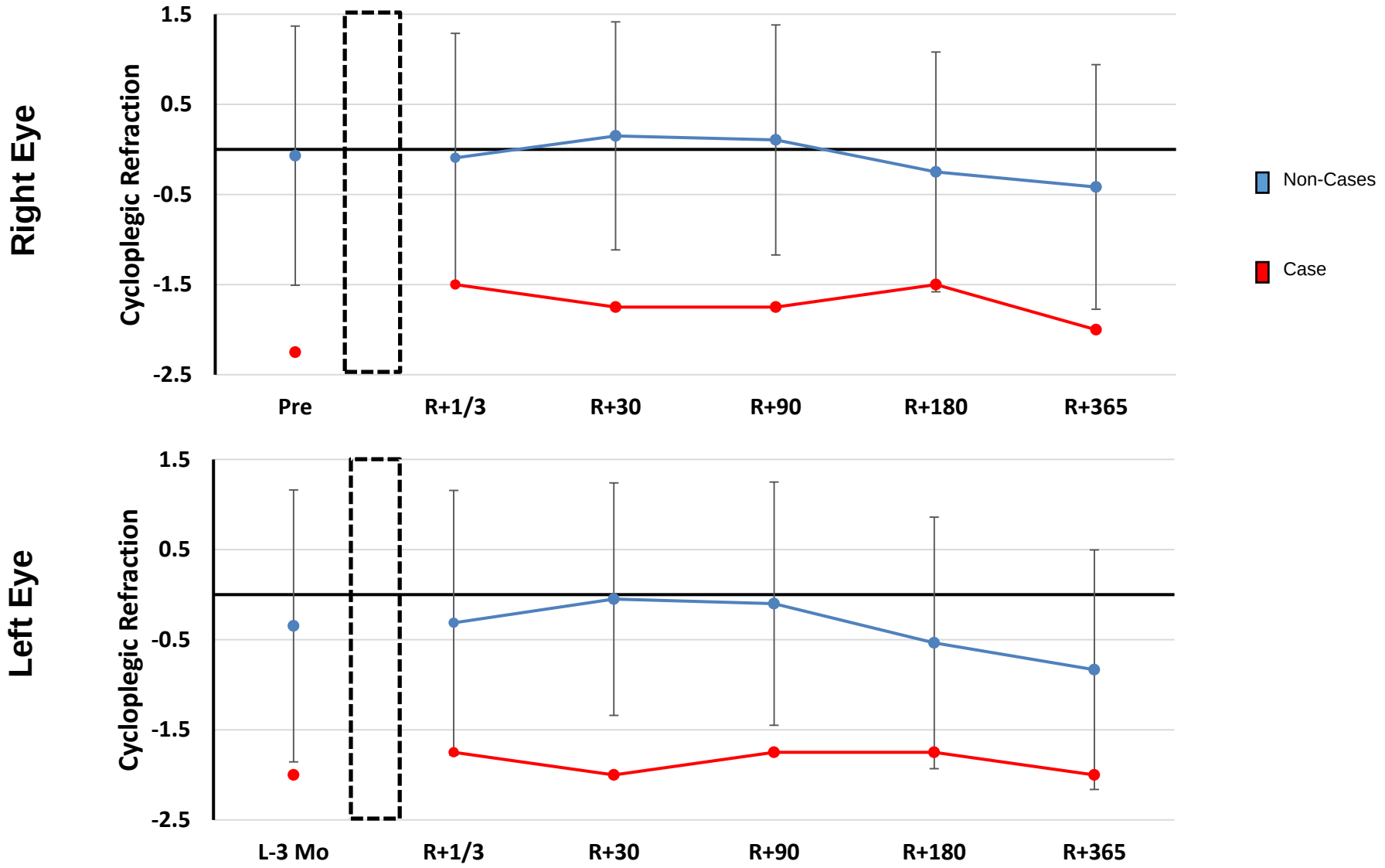
Choroid Thickness

Preliminary Data



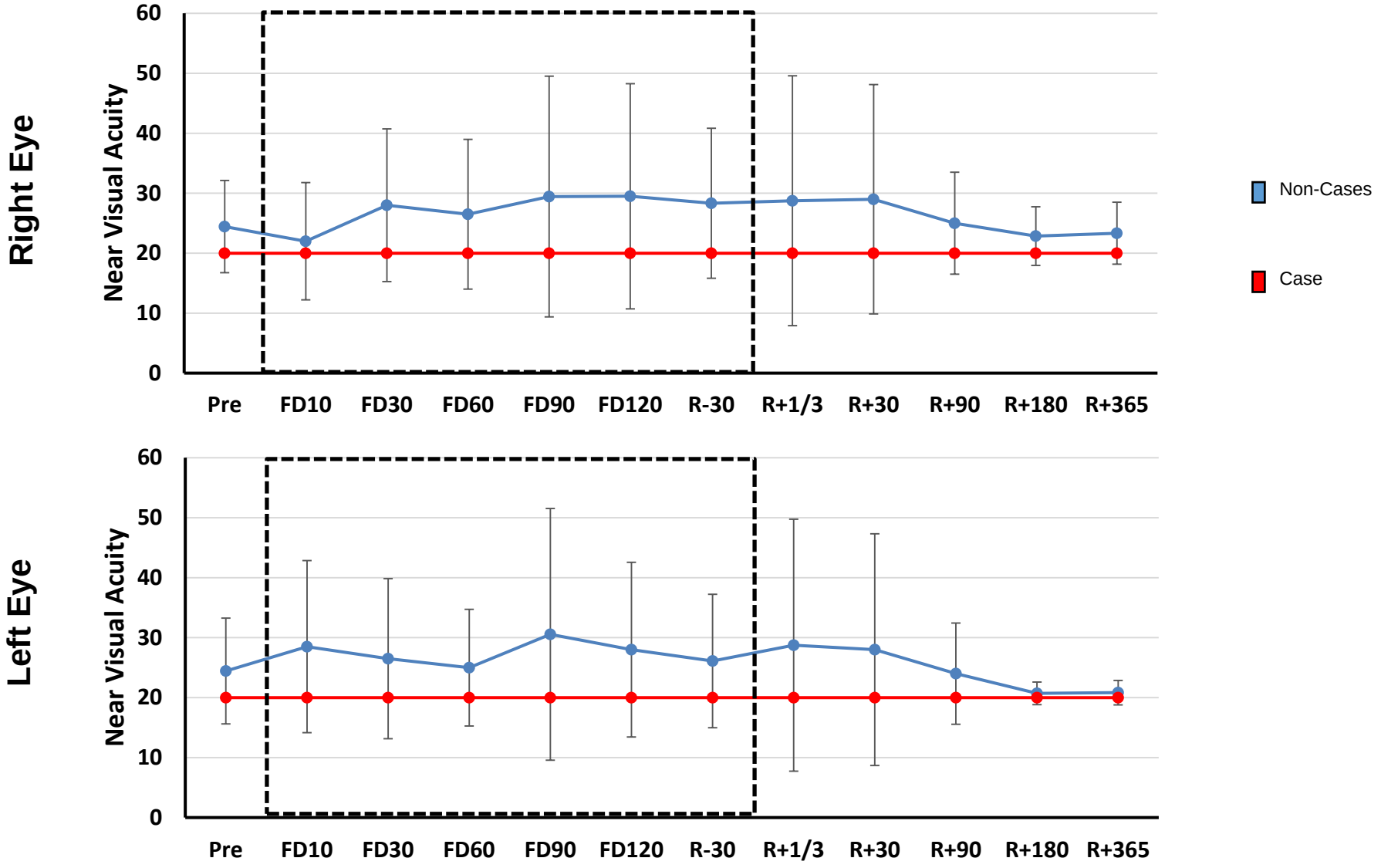
Cycloplegic Refraction

Preliminary Data



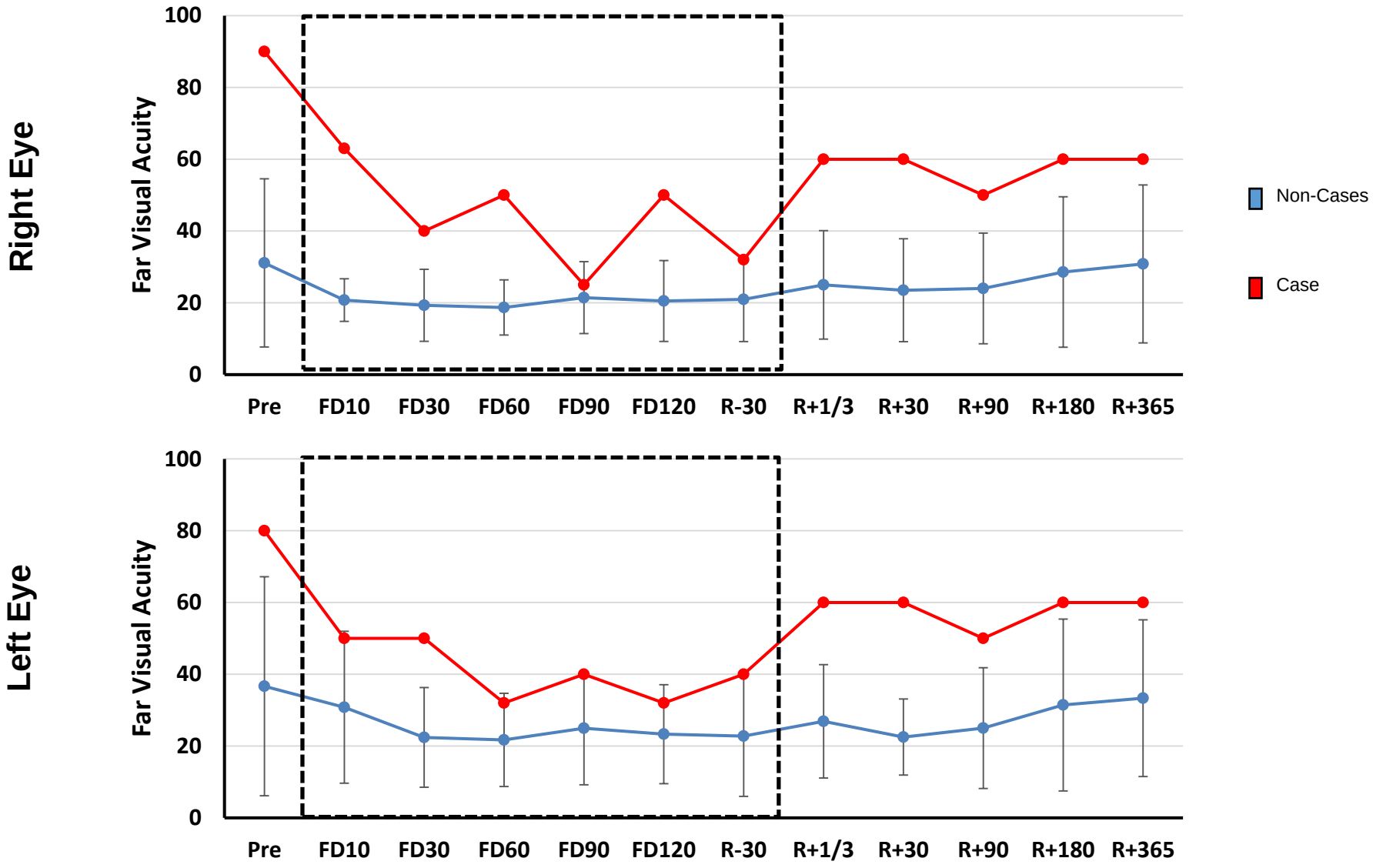
Near Visual Acuity

Preliminary Data



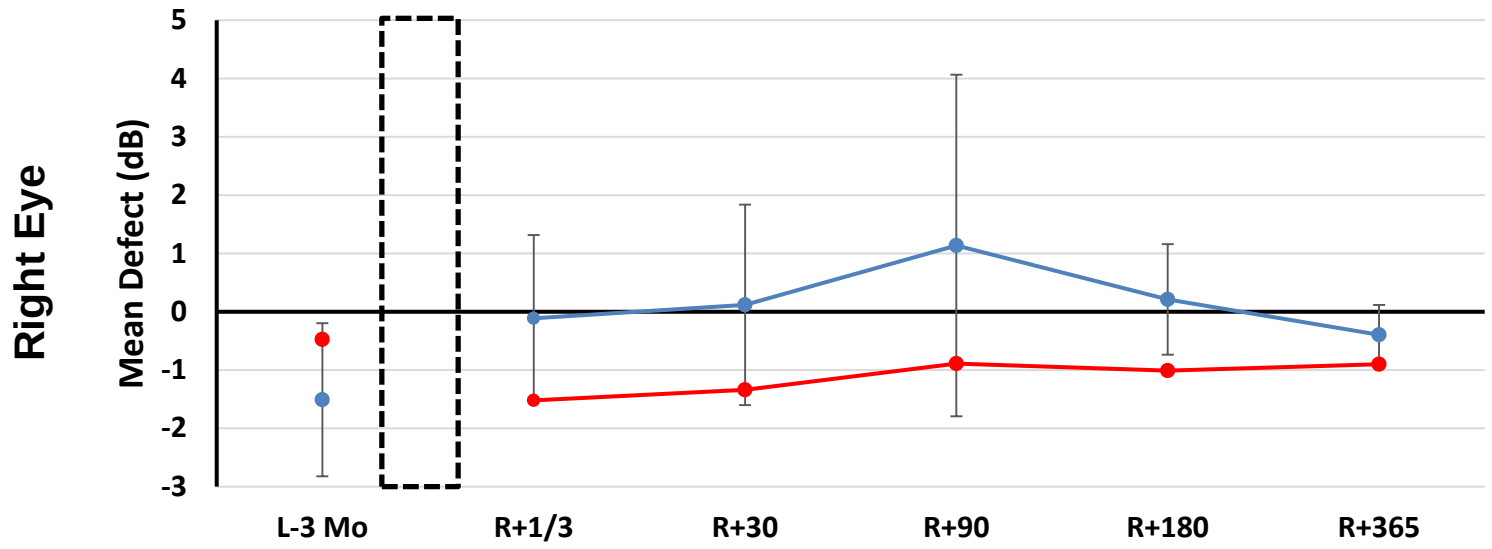
Far Visual Acuity

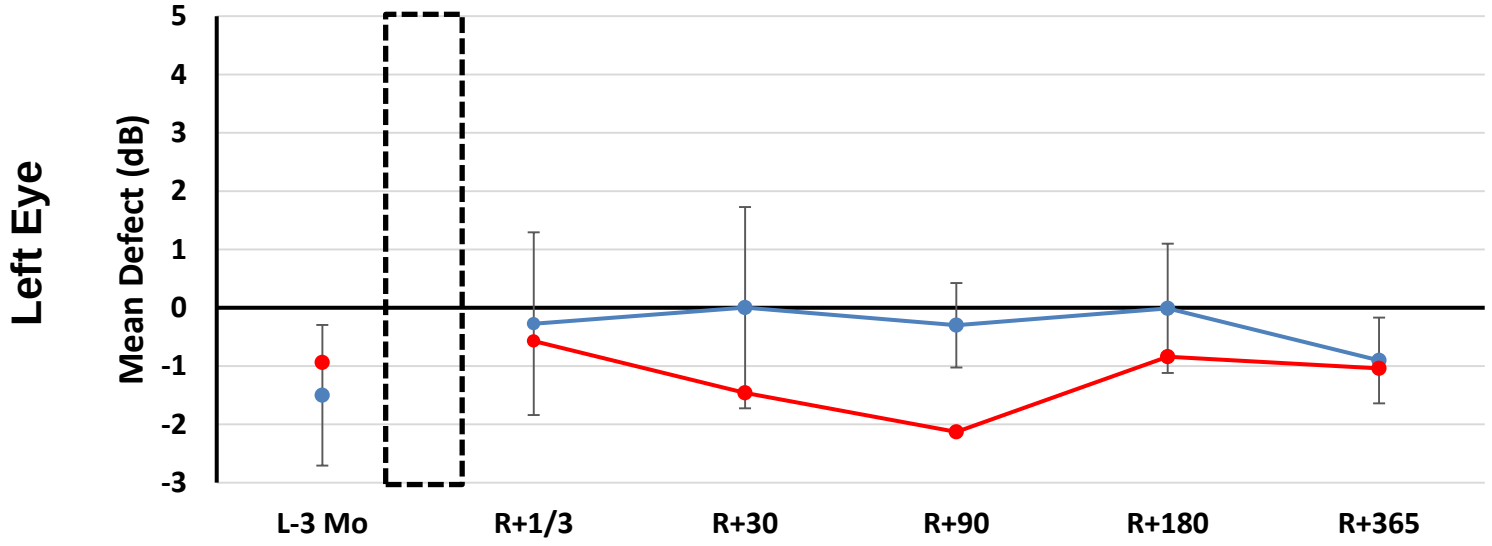
Preliminary Data



Visual Field Mean Defect

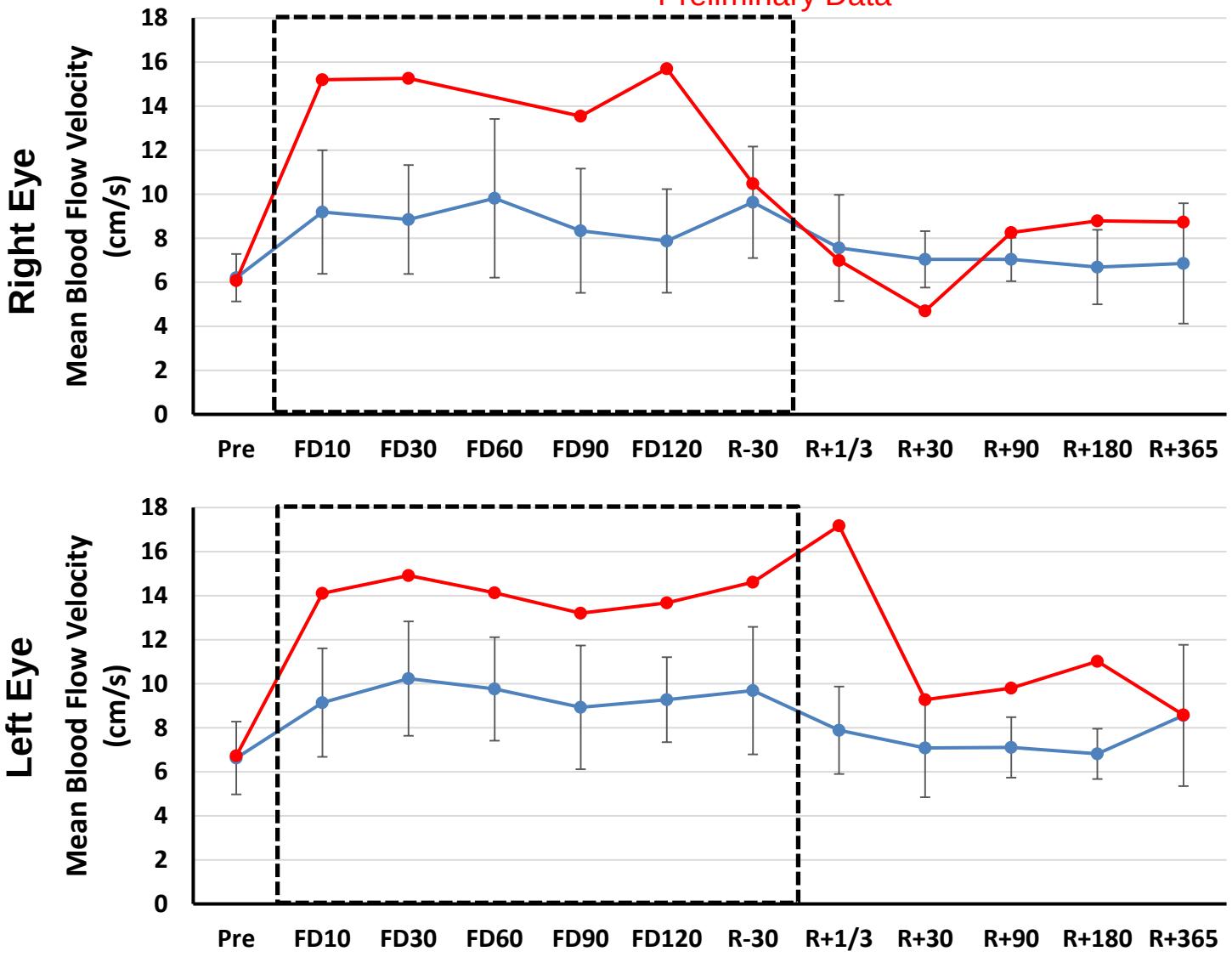
Preliminary Data

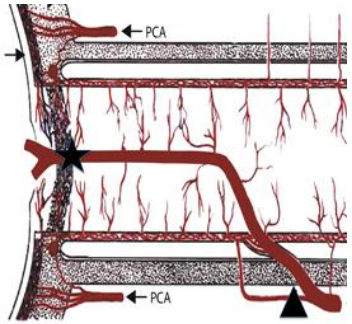




Central Retinal Artery Mean Blood Flow Velocity

Preliminary Data



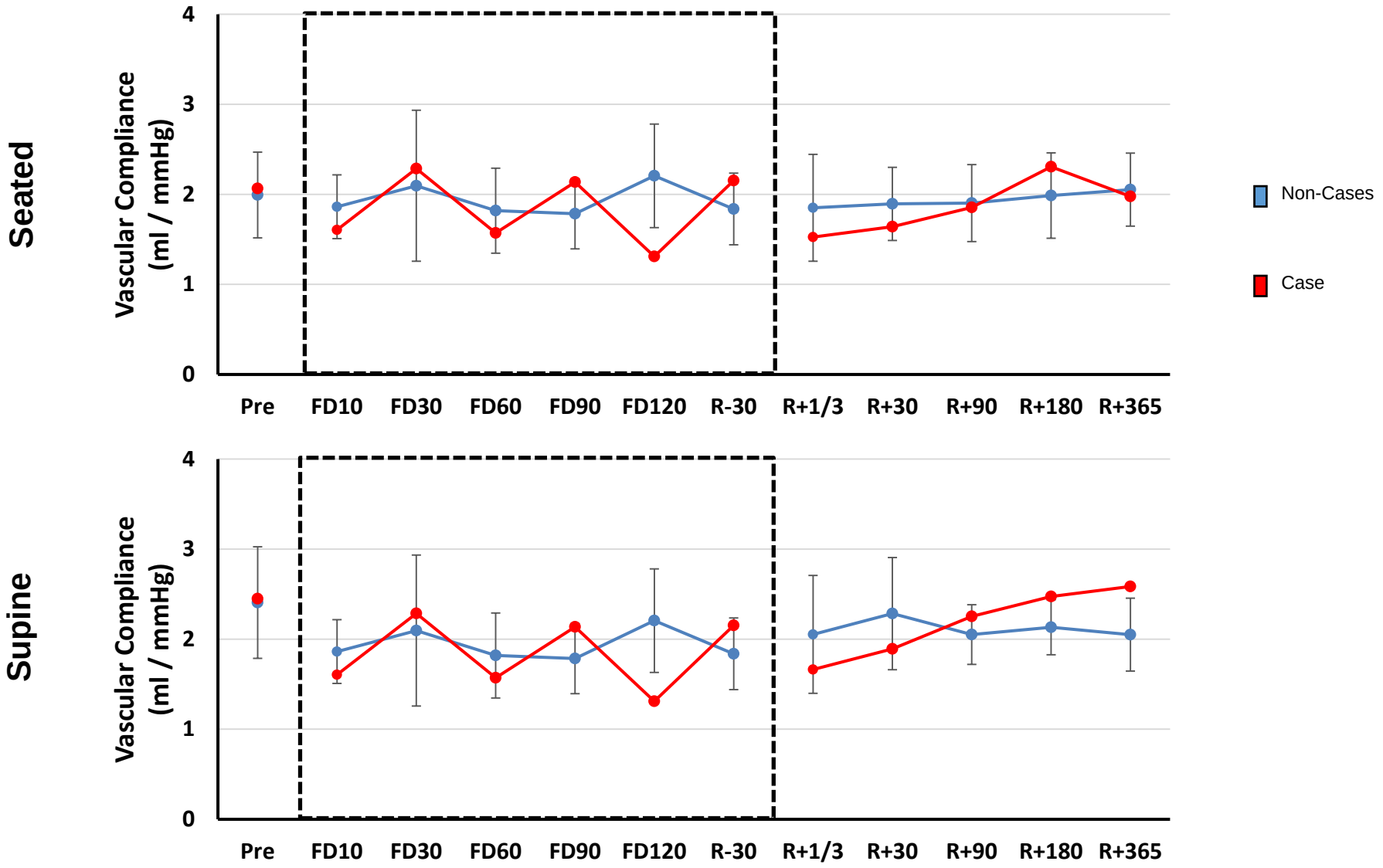


Central Retinal Artery

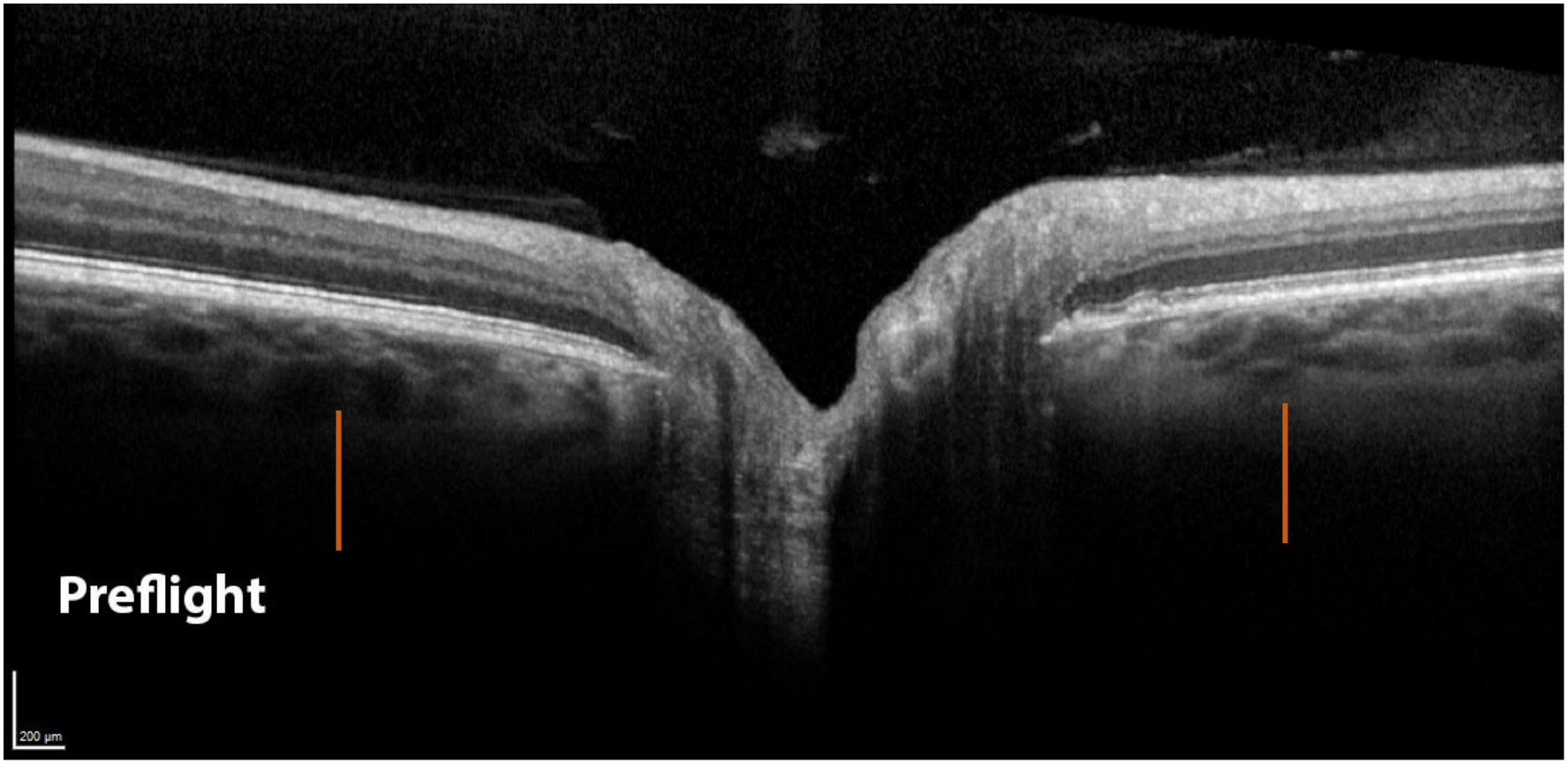
Hayreh et al 1977

Vascular Compliance

Preliminary Data



Optical Coherence Tomography

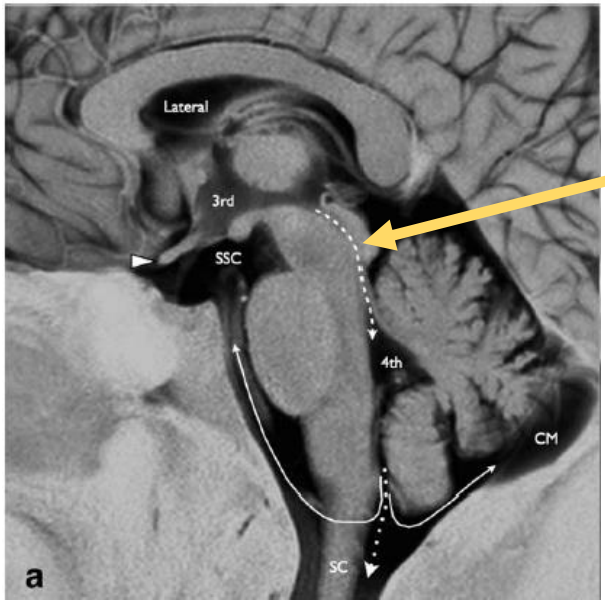


- Orange lines are approximate location of clinical circle scan.
- Note thickening and upward movement of optic disc.

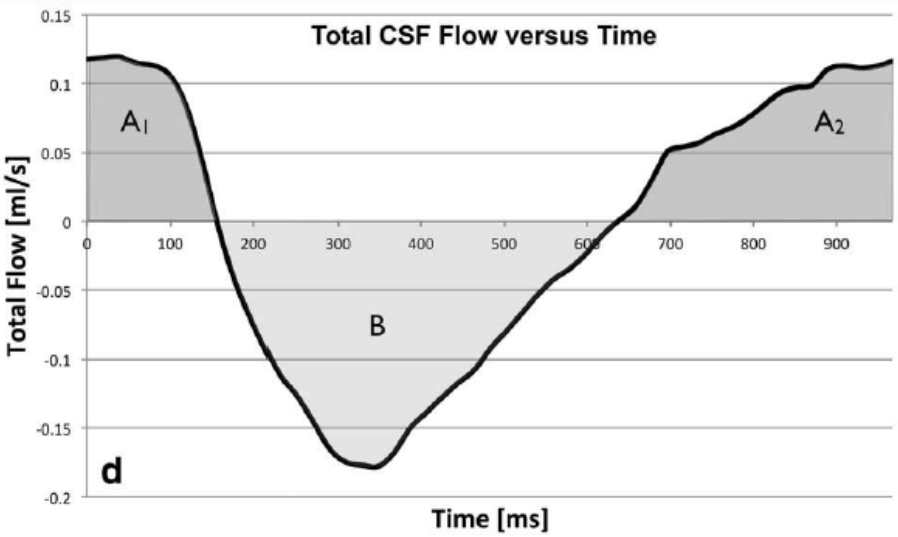
Hydrodynamics of Cerebral Spinal Fluid Flow

CINE phase-contrast MRI flow quantification used to assess cerebral spinal fluid flow hydrodynamics through the cerebral aqueduct.

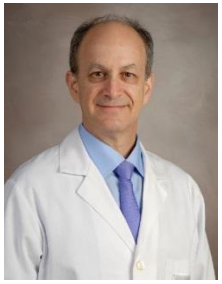
Key outcome measures:
Cerebral spinal fluid pulsatility
Cerebral spinal fluid production rate



Cerebral Aqueduct



Kramer *et al.* J Magn Reson Imaging, 2015



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The University of Texas Health Science Center at Houston

Future Work

- Cerebral blood flow regulation during tilt
- Total body vascular compliance
- Ocular structural (OCT) and functional (visual fields) relationships
- Clinical impression and grading of ocular and brain MRI
- Globe flattening quantification (MRI)

Acknowledgments

International Space Station Medical Projects

Medical Operations

Remote Guiders

- Ultrasound
- OCT
- Tonometry
- Vision Testing